Artificial incubation and growth observation for the nestlings of Great Bustard *(Otis tarda)*

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Abstract: Growth indicators including weight, body length, wings length, tail length, tarsus, gape, the third toe and head width of 21 nestlings of Great Bustard *(Otis tarda)* were measured and investigated in Harbin Zoo, Harbin, China during 1999-2002, and methods on successfully fostering nestlings of the bird were also summarized in this article. The results showed: the Great Bustard is a kind of premature bird and its birth weight was 86.31±3.56g (N=21); environmental temperature for the neonatal nestlings should be controlled at 36°C; the feeding principle "having many meals but little food at each" for the nestlings should be followed; since six weeks after birth, nestlings of both gender began to show significant difference in body weight, the weight of male was 1.8 times of that of the female after fourteenth week, and by weight and body figure sexual identity could be easily discerned when 3 or 4 months old; There is no significant difference in growth and development of all organs between male and female nestlings and organ growth curves were fit into Logistic equation.

Keywords: Artificial incubation; Great bustard; Nestlings; Growth
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Introduction

The Great Bustard (Gruiformes, Otidae, *Otis tarda*), also called Di pu, Lao pu and Yang xupu, has been classified as Rank I endangered species in China (Wan *et al.* 2002) and listed into Appendix II (Yu *et al.* 1983) of CITES. Since 19 century. The population of Great Bustard in the wild had been decreased dramatically, and presently there are 30 000 individuals in the world and 3000 in China (Kong *et al.* 2004). The Great Bustard contains two subspecies, *Otis tarda tarda* and *Otis tarda dybowskii*. *Otis tarda tarda* distributes in Europe (Germany, Poland, Hungary) and west Asia (India, Russia and China) and *Otis tarda dybowskii* lives in eastern Asia (Russia, Mongolia, China, Korea). Both of them are spotted in China, *Otis tarda tarda*, disperses in the west of the Xinjiang Autonomous Region of China (Liu *et al.* 2001) while *Otis tarda dybowskii* mainly distributes in central and western China (Zheng 1987), and their distribution areas show no overlaps.

As an indicative species of prairie ecosystem, Great Bustard lives mainly in open-broad prairie and half-desert areas, and moreover its sensitivity to environmental changes makes its existence or not become indicator of the environmental quality in some areas. The breeding domains are in the Xinjiang Autonomous Region, the Inner Mongolia Autonomous Region, and wintering areas cover the North China (Liu 1997) and the Yangtze valley..

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Until now, no report is found concentrating on reproduction, fostering of nestlings in captivity, and determination of some necessary growth indicators of the Great Bustard. In this article, we introduced our study on artificial incubation, growth indicators as well as the comparison between male and female individuals of Great Bustard for understanding and predicting the living habits and growth of the bird. Also this study can provide reliable data for further research on breeding, reproduction, conservation and reintroduction of the Great Bustard.

Materials and methods

Nestling resource

The experimental nestlings were hatched artificially from eggs picked from the Xing'an League of the Inner Mongolia Autonomous Region. Through artificial rearing and domestication, these nestlings have adapted to the environment of Harbin ZOO, which lay a foundation for high natality and low mortality. We also pick eggs according to the egg-complementary habit of bird and obtain nestlings through artificial rearing and field surviving methods (Sun 2001; Zhao 2001).

Breeding and management

Great Bustard is a kind of premature bird and could stand independently soon after birth. After 24 h of birth, nestlings were put into natal crates with lights of 60W, and in 5 days the infant bustard was moved out of incubator and exposed to sunlight. Next, nestlings were shifted to nestling caring beds with electric tick when they grew to 10-12 days old. No light was provided at night to make nestlings have good rest. Two months later, nestlings were moved to breeding

cages outside the incubation room.

Forage and feeding

In caring stage, forage includes bread worms, crucian, boiled eggs, beef strip and regular vitamin, yeast, fish liver oil, and trace elements, etc. Nestlings were fed after 24 h birth and they showed stronger swallow ability. With the assistance of that the feeding process are easily to be induced. In the first three days, nestlings were fed with bread worms, beef or fish strip, and 3 days later, when nestlings began to feed themselves, a mixed diet comprises of bread worms, beef, fish strip, boiled eggs and powder was provided. The forage could be mixed with a little water and kneaded into lump. At the same time coarse sands were provided for freely taking. To prevent Calcium lacking caused by trace element and over-quick growth, the principle of "having many meals but little food at each" was followed. The feeding times per day were 5, 4, 3, and 2 for 2–20-day-old, 20–60-day-old, 60-day-old, and 100-day-old nestlings, respectively.

Methods

During 1999-2002, growth indicators of total 21 successfully survival Great Bustard nestlings were observed and recorded in the Harbin Zoo, Heilongjiang province, China.

The hatcher (Model 9F-552) made in Wuxi, Jiangsu Province was used in this experiment. This kind of device with good quality can automatically control temperature and moisture. Semiconductor automatic temperature controller was used to control moisture. Temperature was monitored by hair temperature and moisture determination machine (Tianjin Machine Manufacture Company and Germany).

Weight of Great Bustard was measured by a balance with precision of 0.1 g. Gape, tarsus, the third toe, head width, and tail length were determined by ruler with precision of 0.1cm, and the body length and wing length were measured by soft ruler with precision of 0.1cm (Wang 1998).

Results and discussions

Successful artificial incubation largely depends on breeding and management. Additionally, climate should be taken into account. Usually there is no significant difference in growth and development of all organs between male and female nestlings and organ growth curve is fit for Logistic equation.

In rainy and hot summer days, the birth process could be easily aborted, even due to a little carelessness. Therefore, strict and correct strategies and management are essential in this stage. More attention should be paid to appropriate temperature, feeding amount and movements of nestlings.

Incubation temperature

Temperature is a very important for the neonatal. The hatching temperature was about 36℃, then caring temperature decreased by 1℃ per day. Nestlings are weak and require very strict environmental temperature. When temperature arrived at 24-28℃, nestlings should be moved to incubation beds. Some studies had proved that this living circumstance was suitable. The Great Bustard favorites high temperature and sand bath, which is relevant to living habits in wild.

Exercises

Exercises like walking and running are essential for nestlings' growth, and they like to move in flock. Usually one moves, others follow, and then the whole flock act. Before feeding, raiser could induce nestlings with food plates to run 2-3 rounds to exercise and enhance appetite.

Appetite

Appetite per day had no great difference for the nestlings of the Great Bustard (Li 1994), and it would increase along with age (in days) and finally get to a stable level at certain age. In nestlings' daily food, crude protein took up 10%–13%, fat 1%–3%, metabolic energy 5-6 kJ/kg, calcium 0.8%–1%, phosphor 0.4%–0.5%, and crude fiber 1-2%.

In consideration of the Great Bustard owning well-developed cecum and favoring flowers and fresh leaves, we increased percentage of vegetative food and controlled 1%-2% crude fiber in daily food. For three-month-old nestlings, the percentage of flesh in diet should be controlled below 20% to avoid stomach and intestine inflammation.

Weight

The weight of neonatal nestlings was 86.31±3.56 g (n=21), which was a little lighter than that of wild one (96.8 g) (Tian 2001). Within the first 3 days after birth, weight of nestlings decreased continuously, with reduction of 5-9g each day, and since the fourth day, body weight began to recover. The curve of weight was fitted into the Logistic Equation (see Table 2). Figure 1 showed the significant difference in weight between male and female nestlings occurred at the sixth week (37 days old) (Xu 2002). Weight of male nestlings was 1.8 times of that of the female in the fourteenth week (100 days old). Gender differences could be easily discerned through weight and body figure when nestlings were 3 or 4-month-old.

Table 1 showed the daily increase in weight of nestlings. In the first week, the average daily increment of weight was less. Daily weight increment of male nestlings was more than that of female ones, especially after the sixth week. Daily weight increment was 48 $g \cdot d^{-1}$ averagely for male nestlings, and 26 $g \cdot d^{-1}$ for female nestlings. The difference in weight increase between male and female nestlings may be due to different physiology conditions of both gender.

Outer organs growth

Figure 2 and 3 showed all the outer organs of Great

Bustard nestlings grew slowly and the growth curve was nearly flat within 14 weeks. Growth of tarsus, gape, and the third toe were concentrated at the early stage, while others such as body length and weight mainly developed in the later stages (2-3 month old).

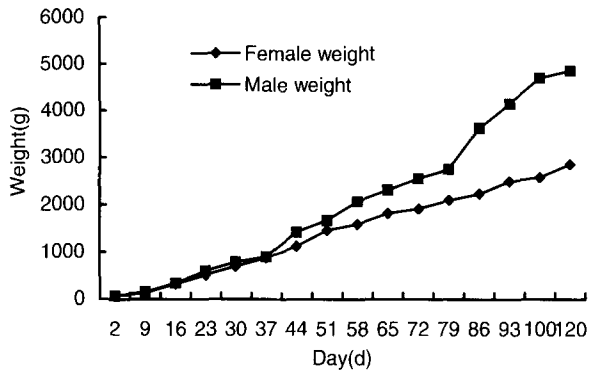

Fig. 1 Weight curves of the Great Bustard nestlings

Table 1. Average daily weight increment of the Great Bustard nestlings during 1-14 week

Week	Daily increment of weight /g·d^{-1}	
	Male	Female
1st	11	9
2nd	27	27
3rd	36	27
4th	26	24
5th	16	26
6th	75	36
7th	34	48
8th	57	17
9th	34	35
10th	35	13
11th	28	46
12th	126	19
13th	75	37
14th	78	13

Body Length: daily increment in body length of nestlings was 7.4 mm for the male and 6 mm for the female from the 1st week to 14th week. In the first week, the average daily increment of body length was 4.3 mm for the male and 2.9 mm for the female. Development of body length gradually ceased after 14 week.

Wing Length: The wing of Bustard nestlings grows quickly from 2nd to 9th week, with an averaging growth rate 6.8 mm /d for the male and 5.8 mm for the female. From 9th to 14th week, wing growth become slowly, with an average growth rate of 3.8 mm/d for male nestlings and 2.7mm/d for female.

Tail Length: Bustard nestling began to have tail feathers since 10-12 days after birth. For male individuals, the growth rate of tail was 2.4 mm/d in the 3rd-4th week and 3.7 mm/d in 5th-10th week, while that of female individuals was 2.3 mm ·d^{-1} and 3.6 mm·d^{-1}, respectively. No significant differences in growth of tail length were found between male and female nestlings during fast growing period.

Tarsus: growth of tarsus was mainly in the early days. The growth rate of tarsus for male nestlings was 1.9 mm/d from 1st to 9th week and 0.8 mm·d^{-1} from 10th to 14th week. The growth rate of tarsus of the female was similar with that of the male, but the fast growing period was two weeks shorter than that of female ones.

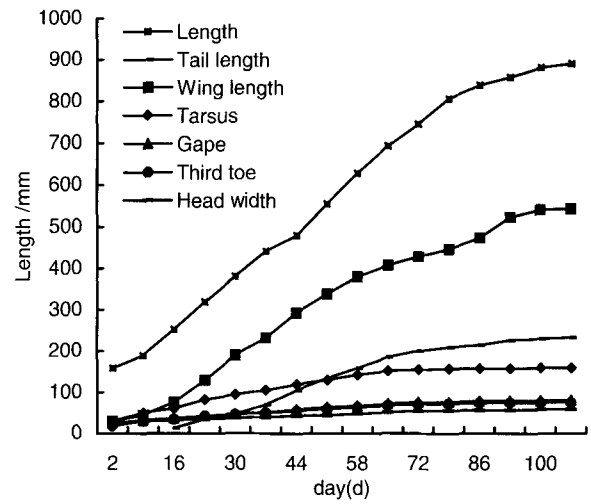

Fig. 2 Outer organs growth curves of the male Great Bustard nestlings

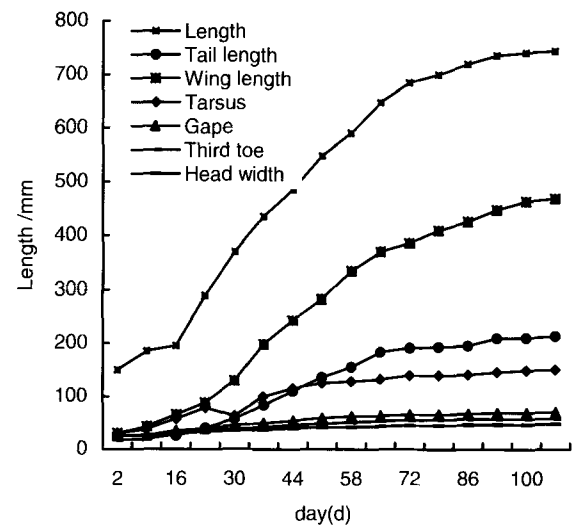

Fig. 3 Outer organs growth curves of the female Great Bustard nestlings

Gape, the third toe and head width of nestlings increased by 3.2, 4.2 and 2.1 times in length for male nestlings and 2.8, 3.4 and 1.8 times for female ones at age of 100 days. The increase of head width was linear, (regression equation was y=2.606+0.037x (r=0.998) for the male, and y=2.73+0.023x(r=0.9704) for the female).

Single factor analysis of variance revealed there had no significant differences for all growth indicators, except the third toe ($p<0.5$), between both gender.

Logistic Equation of weight and outer organs

Comparisons were made by Logistic regression (Yin 2002) of each growing indicator and certain conclusion can be drawn as follows:

K value: All growing indicators of the male Great Bustard were larger than those of the female (see Table 2), especially weight. Weight of the male nestlings was 2 times of that of the female. Thus, sexual identity of Great Bustard nestlings could be identified by growing indicators such as weight, body length during nestling development stage.

R value: The average instant growing rate was nearly equivalent between male and female individuals, but the growing period was different.

Yielding point: this value could represent the mature time. The yielding point value of tarsus, gape, and third toe were comparatively small, which implied the fast growing period lied in the early days. The yielding point value of body weight was highest, which indicated body growing was in the later days. Body length, wing length and tail length ceased to grow in the middle growing stage.

Table 2. Weight and outer organs of Great Bustard nestlings (1-14 weeks) described by Logistic equation

factors	sex	K value	R value	t(10-90)	Yielding value	Logistic equation
Body weight	♂	4800	0.054	80.9	67.8	$4800/(1+e^{3.661-0.054t})$
	♀	2700	0.051	87.1	48.6	$2700/(1+e^{2.479-0.051t})$
Body length	♂	90	0.047	94.5	38.6	$90/(1+e^{1.814-0.047})$
	♀	75	0.053	83.2	30.6	$75/(1+e^{1.622-0.053t})$
Wing length	♂	55	0.053	82.6	41.8	$55/(1+e^{2.215-0.053t})$
	♀	47	0.056	78.4	35.6	$47/(1+e^{1.994-0.056t})$
Tail length	♂	23.5	0.079	55.7	46.9	$23.5/(1+e^{3.705-0.079t})$
	♀	21.5	0.069	63.1	43.3	$21.5/(1+e^{2.988-0.0691t})$
Tarsus	♂	18.5	0.044	99.8	29.0	$18.5/(1+e^{1.276-0.044t})$
	♀	15.5	0.051	86.5	22.8	$15.5/(1+e^{1.163-0.051t})$
Gape	♂	8.2	0.044	98.9	21.6	$8.2/(1+e^{0.0950-0.044t})$
	♀	7.0	0.053	83.2	16.0	$7.0/(1+e^{0.848-0.053t})$
The third toe	♂	7.6	0.053	83.8	19.5	$7.6/(1+e^{1.034-0.053t})$
	♀	5.8	0.054	81.9	16.7	$5.8(1+e^{0.902-0.054t})$

Description of other aspects of nestlings

Great differences would emerge during the growing process of fledging birds (Zhang 1985). For the Great Bustard, nibs, tarsus and paws of nestlings were all lead black. Quill-coverts covered body, tawny or buff on back, with speckle (like brown warm) in the middle part of back; neck, breast, abdomen and legs were puce. The neonatal of the Great Bustard bird was weak and could stand up and walk after 24 minutes of birth. At age of 5 or 6 days, nestlings could have sand bathes, and at age of 9–10 days learn to gather food. Twenty or thirty-day-old nestlings appeared to antagonize frightening, and at age of 30–35 days, nestlings began to try flying. In 50–60 days, feather of nestlings resembled adult individuals, and they gradually lived independently. Weights between the male and female nestlings became different after 60 days of birth. An 80 or 90-day-old nestlings had similar body figure to adult bird. When 100 days old, differences in weight between male and female individuals were very evident (weight of the male was 1.8 times of that of the female) and the body weight at this age approximated to those of the adult individuals.

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